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ABSTRACT

This study investigated the use of a computerized tutorial--Self-Test and Review (STAR)--in a computer-managed general psychology course. STAR consists of four major modules which provide the student with a variety of learning exercises, including practice quizzes, practice final exams, performance reviews, and structured study questions. The purpose of the study was to determine whether students would choose STAR as a study tool, the effect of lecture versus self-paced settings on the use of STAR, whether students who used STAR would perform better than those who did not, and the effect of the timing of feedback in STAR on performance. Students were enrolled in either a lecture or self-paced setting. Students in lecture sections met in the classroom for a traditional lecture, discussion, and classroom activities. Students in self-paced sections met in a computer-managed testing center. Analyses of data on course performance and STAR usage indicate that: (1) 49% of the 1,136 subjects used STAR; (2) lecture versus self-paced settings did not affect the use of STAR; (3) the timing of feedback did not have an impact on performance; and (4) students who used the STAR tutorial performed well in the course and, as a whole, better than those students who did not use the tutorial. It is concluded that, while the results were generally positive, the findings of the study create other research questions concerning the impact of modification of lecture settings, the impact of STAR tutorials in other course formats, and the ways in which STAR influences student comprehension. (39 references) (DB)

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# STAR: A Computerized Tutorial in General Psychology

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Abstract

The use of a computerized tutorial, STAR (Self-Test And Review), in a computer-managed general psychology course was investigated. Students voluntarily used the tutorial to study for multiple choice quizzes which constituted a major portion of their course grade. Students were enrolled in either a lecture or self-paced section. Lecture sections met in the classroom for traditional lecture, discussion, and classroom activities. Self-paced sections met in a computer-managed testing center to study and take chapter quizzes. Results indicate that across both section types, the students who used STAR as a study tool, achieved better course performance than the students who did not use STAR.

The use of computers in education is becoming nearly as common as the chalkboard. Instruction in reading, writing, and arithmetic are all being facilitated with the use of computers. Results from the evaluation of computers in education have been generally favorable. A meta-analysis of 51 computer-based instructional programs (Kulik, Bangert and Williams 1983) reported an increase in final examination scores of approximately .32 standard deviations. Niemiec and Walberg (1987), in a combination of CAI reviews, found overall achievement with CAI to be .42 standard deviations units higher than traditional instruction. Student attitudes toward computers and courses involving computer use have also been reported to be positive (Kulik, et al., 1983). Not surprisingly, the attitudes of instructors have also been reported to be favorable since the amount of time spent on administrative work is substantially reduced (Halcomb, Chatfield, Stewart, Stokes, Crase, & Weimer, 1989).

To say, however, that computer-based instruction is beneficial to students requires some qualification since the way in which computers are actually implemented into the instructional process can differ considerably. Questions such as how much control the students have over computerized instruction, how the instructional material is presented to the student, and how performance feedback is presented only scratch the surface of the many factors that may impact program effectiveness. These questions, therefore, have been the subject of much research and controversy.

Learner Control

Computer-assisted instruction may vary from applications where no human instructor is required, to instructional modules designed to accompany usual course material or to enhance normal classroom activities. Each method employs a different level of learner control. In the former case, the student follows a predetermined sequence

of instruction while in the latter, instruction may follow several paths and is controlled by the student. These two levels of control within instructional modules have been shown to significantly affect retention and comprehension of presented material (Gray, 1987, O'Day, Kulhavy, Anderson, & Malczynski, 1971). It has been reported that students who are given their own control over the direction and sequence of the instructional material retain less information than students under control of the instructional program (Steinberg, 1977; Tennyson, 1980; Ross and Rakkow, 1981; Goetzfried and Hannafin, 1985; Garhart and Hannafin, 1986). Some students, however, seem to prefer the conditions where they controlled their own instruction (Steinberg, 1977).

One possible explanation for this finding relates to the ability of a student to estimate his or her own learning progress. In general, it is suggested that students are very poor monitors of their own comprehension and in some cases end instruction earlier than they should (Garhart and Hannafin, 1986). This phenomenon has been labelled, in the reading comprehension literature, the illusion of knowing by Glenberg, Wilkinson, and Epstein (1982) and has been demonstrated repeatedly by students overrating their comprehension of instructional material even when the text was made to be contradictory.

To explore this problem further, researchers have investigated ways of presenting printed text so that reader comprehension monitoring may improve. Much of this research has involved the embedding of questions throughout text for students to answer while reading. It has been found that the answering of such inserted questions facilitates learning (Frase, 1968; Andre, 1979; Kiewra and Benton, 1985; MacLachlan, 1986; Merrill, 1987), improves comprehension monitoring (Pressley, Snyder, Levin, Murray, and Ghatala, 1987), and elicits deeper processing of the course material, (Anderson, Anderson, Dalgaard, Wietecha, Biddle, Paden, Smock, Alessi, Surber, and Klemt, 1974).

Using tests to facilitate learning is very similar to answering questions while one reads. In 1968, Keller proposed a method of self-paced programmed instruction in which students must achieve a certain level of mastery through repetitive testing before being allowed to go on to additional course material. Implementation of this method (and slight modifications) have been reported to be superior to traditional lecture approaches (Stinard and Dolphin, 1981, Halcomb, et al., 1989).

Supplemental educational materials, such as study guides or workbooks accompanying most textbooks often supply practice tests and exercises. These materials are often optional to the student and when they are used, students are often found to copy the provided answers rather than attempt to answer on their own (Anderson, Kulhavy, & Andre, 1972). Computerized lessons obviously can provide a solution to this problem, but have not always been found to be superior to written study guides (Sawyer, 1988).

Feedback in Instruction

In addition to providing varying levels of learner control, computerized instruction further allows flexibility in the type of performance feedback the student receives although exactly when in the instructional process feedback should be presented has been the subject of much research and controversy. Research investigating instructional feedback suggests delayed feedback of at least 20 minutes (Sturges, 1978) to 24 hours (Sassenrath and Yonge, 1968, 1969; More, 1969; Sturges, 1969; Kulhavy and Anderson, 1972; Sassenrath, 1975; Bardwell, 1981) for optimal long-term material retention. Such a delay in a programmed lesson, however, is often impractical, especially if it is designed for use in a single class or study period. Nevertheless, to assess how feedback can be used in CAI, Gaynor (1981) investigated immediate and delayed feedback with computer-based instructional material and found that the effects of each type of feedback were a function

of student mastery level. Students with low mastery of the material gained greater benefit from immediate feedback while those with higher mastery gained more from end-of-the-session feedback. In contrast, Rocklin and Thompson (1985) found that immediate feedback had significantly more performance benefits when a test was easy (when one would assume mastery of the material was high) than when the test was hard (when one would assume that mastery of the material was low).

In light of these results, the role of feedback in instruction remains a debated issue. In the classroom situation, feedback is present in the form of interaction between the instructor and student. During student study time, however, feedback is dependent upon the student's study methods. It seems apparent that computers can be a valuable tool in instruction. The methods in which they are used, however, still needs to be clarified.

General Psychology at Texas Tech University

In the Spring of 1988, an attempt was made to develop a computerized tutorial software program to help students identify and review important concepts, key terms, and important individuals from each chapter of the assigned textbook (Zimbardo, 1988). The tutorial was designed to be controlled by the student, to contain self-tests, and to provide frequent feedback of performance. Many of the ideas which guided the development of the tutorial were based upon many years of observing the teaching of the general psychology course at Texas Tech.

In the early 1980's, the department was faced with the problems of teaching a large general psychology course and were constantly experimenting with different teaching methods. Finally, with the implementation of a computer-managed instructional system[1], the amount of time instructors spent on course management activities was reduced, the

amount of time instructors focused on individual student needs was increased, and an optimal learning environment for the students was provided (Halcomb, et al., 1989). Since its implementation, performance in the course has proven to be consistently good and student/instructor attitudes have been generally positive. It was hoped that the addition of a computerized tutorial would add to the conducive learning environment and especially help those students needing more direction in their study.

## STAR: A Computerized Tutorial

The tutorial, Self-Test And Review, (STAR) is a menu-driven CAI program designed to accompany the introductory psychology textbook titled Psychology and Life, 12th edition (Zimbardo, 1988) and study guide (Fraser and Zimbardo, 1988). STAR was written by graduate students and faculty in the department of psychology at Texas Tech University.[2]

STAR consists of four major modules which provide the student a variety of learning exercises - practice quizzes, practice final exams, performance reviews, and structured study sessions.

Practice quizzes are 10-item multiple-choice quizzes covering each chapter in the textbook. Each practice quiz provides the student with extensive feedback to each question answered incorrectly. This feedback includes the question missed, the student's response, a subtopic and page range in the textbook corresponding to the topic of the question, a specific page in the textbook from which the question was chosen, and a learning objective in the study guide.

Practice final exams of 50 or 100 multiple-choice questions are also available with the STAR tutorial. Questions are randomly selected from each chapter of the textbook to provide a comprehensive exam. Feedback for the final exam consists of the student's total

score out of 50 or 100 total questions. Individual question feedback, as provided in the practice quizzes, is not provided.

Students may also review their performance on the practice quizzes in any of three ways - by question type, by chapter topic, or by quiz score. Each review, furthermore, provides a bar graph summarizing the student's quiz performance.

The study session allows students to explore a guided review of each chapter, to receive tips on how to take a multiple-choice quiz and to explore the SQ3R [Study, Question, Read, Recite, and Review, (Robinson, 1970)] method of study. The guided review provides a breakdown of each chapter from main topic to subtopic to key terms so that a student can identify the important information within each section of a chapter. The topics and subtopics correspond to the topics and subtopics given in the practice quiz feedback as well.

It must be emphasized that the STAR tutorial was designed for the specific purpose of use along with the textbook. In other words, the practice quizzes are meant to be open-book quizzes where the students look up the feedback information while the question was still on the computer screen. This interactive study with both the textbook and the computer was observed to be very effective for the students in the computer-managed instructional course at Texas Tech. This observation has also been reported and confirmed elsewhere when compared to traditional non-computer study (Grabe, Petros, and Sawler, 1989).

## A Description of the ISC Testing System

The STAR tutorial is used in conjunction with the general psychology course. The course is administered and managed via a Digital Equipment Corporation MicroVAX II computer and students follow a modified content mastery approach to instruction

(Halcomb, et al., 1989). Furthermore, each student is required to take twelve 10-item multiple-choice chapter quizzes covering the textbook material. The students may take each quiz as many times as desired. Quiz questions are randomly selected from a large pool of items such that a student receives a unique, yet comprehensive quiz on every attempt. Students monitor their performance through feedback provided after each quiz and through a computerized performance record.

The total pool of students enrolled (about 1500 per semester) is divided into sections of no more than 50 students which are supervised by graduate teaching assistants. The majority of the student sections (lecture sections) meet at a scheduled time in a classroom for discussion, lecture, and demonstrations based upon course material. Students take required computer-generated quizzes outside the regular class period. Other sections (self-paced sections) meet in the Instructional Systems Center (ISC), rather than the traditional classroom, to study and to take computer-generated quizzes at their own pace. Students in both section types earn bonus points by participating in research experiments, finishing all the quizzes with a "B" average or better by a specified deadline, writing a paper, and by attending and participating in class. A comprehensive final examination consisting of 100 multiple-choice items is additionally required of all students.

## Purpose

The purpose of this study was to investigate the effects of the adlib usage of the STAR tutorial in the general psychology course. Several questions were addressed:

- Do students, if given the opportunity, use STAR as a study tool for the computer-managed psychology course?
- Do the students who use STAR to study perform better in the course than those students who do not use STAR?

- Does the classroom environment (lecture or self-paced) have an effect on how (or how much) STAR is used or how students perform in the course?
- Assuming some students use STAR, does the timing of the presentation of question feedback effect how (or how much) it is used or how students perform in the course?
- Are there any predictive measures (e.g. academic standing, achievement scores, etc.) of whether a student will use the STAR tutorial or how a student will perform in the course?

Dependent Variables

The major dependent variables in this experiment included course performance and STAR usage measures. Course performance was operationally defined in several ways. These included average final quiz score (average of last attempt score across all chapters), final exam score (out of a possible 100 points), total points earned through bonuses (including experimental bonus points, written paper points, and class participation points), and average number of quiz attempts (actual quizzes for course credit).

Use of the STAR program was operationally defined in terms of the frequency of use. Total number of STAR practice quiz attempts was used to define STAR usage since it was determined that this was the primary module used by the students. Those students who used STAR were divided into quartiles according to the number of practice quiz attempts. The top three quartiles were used to define three usage categories labelled high, medium, and low. The number of practice quiz attempts by category ranged from 3 to 10 in the low usage group, 11 to 34 in the medium usage group, and 35 to 200 in the high usage group.

## Method

### Subjects

One thousand one hundred thirty-six Introductory Psychology students served as subjects in this experiment. Participation in this research was part of the actual course curriculum. Therefore, no experimental bonus or extra credit points were offered for participation.

### Materials

Students used the textbook, Psychology and Life 12th edition (Zimbardo, 1988) and the accompanying study guide (Fraser and Zimbardo, 1988). In addition, each student was given a copy of the STAR tutorial on two microcomputer disks. Students also had access to the STAR tutorial via the MicroVAX II computer.

### Procedure

Students were introduced to STAR during an orientation period at the beginning of the Spring 1989 semester. Students were encouraged to use STAR as a method of study, but were not required to use it, or allowed to receive course points for using it. Detailed instructions were given to every student in class about how to operate the STAR tutorial. Students enrolled in 27 sections (17 lecture, 10 self-paced) of the course were randomly assigned to one of two conditions. One of the groups received a version of STAR that presented the feedback after each STAR practice quiz question while the other group received a version of STAR that presented the feedback after each STAR practice quiz. In both cases, the feedback consisted of the question that was answered incorrectly, the student's response, a subtopic and section in the textbook to review, a specific page number in the textbook, and a learning objective from the study guide.

Students used STAR on their own time throughout the course until they were either finished with all twelve chapter quizzes or until the semester ended. At the beginning of the Spring semester, students were given a questionnaire (Lambert & Lewis, 1988) to assess demographic information and computer experience. Students were also asked for written consent to release their SAT/ACT scores, high school rank, and college GPA.

## Results

### Course Performance

Overall, 49% of the students used STAR. Table 1 shows the percentage of users by section type.

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Insert Table 1 about here.

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A 2 x 4 analysis of variance was performed to determine the relationship between section type (lecture, self-paced) and amount of STAR usage (none, low, medium, high) on course performance. Mean and standard deviation values for each of the course performance measures are shown in Table 2.

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Insert Table 2 about here.

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Results indicated a main effect for amount of STAR usage for each of the dependent variables (average final quiz score, $F(3,528) = 15.49$, $p < .0001$, final exam score, $F(3,528) = 12.23$, $p < .0001$, average number of quiz attempts $F(3,528) = 4.54$, $p < .0037$, and total bonus points, $F(3,528) = 10.49$, $p < .0001$. Tukey's HSD test ($p < .05$) was used to

investigate the performance differences between the usage groups and revealed that students who used STAR, at any level, had significantly higher quiz averages, final exam scores, number of quiz attempts, and total bonus points than students who did not use STAR. Additionally, students in the high usage group showed a significantly higher quiz average than the students in the medium and low groups. This relationship is shown for both section types in Figure 1.

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Insert Figure 1 about here.

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A main section type effect was found for average number of quiz attempts, $F(1,528) = 4.92$, $p < .0270$, indicating the self-paced students took significantly more quizzes than did the lecture students ($M = 4.32$, $M = 3.92$ respectively).

Although no interaction was found, examination of Figure 1 reveals a more level function for the self-paced students than for the lecture students. Planned comparisons were conducted for each section type to determine any differences between the usage groups by section type. Interestingly, it was found that non-users in the self-paced classes did not differ in final quiz average, final exam score, total bonus points or average number of quiz attempts from those students who used STAR at any level. Students in the lecture classes who used STAR, however, scored significantly higher on the final exam and earned more total bonus points than non-users and the lecture students classified as high users, had a significantly higher quiz average than students who did not use STAR.

A 2 x 2 analysis of variance was conducted to investigate the effects of section type (lecture, self-paced) and feedback type (after-item, end-of-quiz) on course performance for those students who used the STAR tutorial (those students not using the

tutorial, of course, would not fall into either feedback group). No main effect of section type or feedback type was found.

Further Examination of STAR Usage

A 2 x 2 analysis of variance was used to examine the effects of section type (lecture, self-paced) and feedback type (after-item, end-of-quiz) on actual STAR use. STAR usage measures included total number of STAR quiz attempts, total study sessions, total review performance sessions, total practice final exams, total time using STAR, and total time spent with the STAR practice quiz feedback. Initial examination of these data revealed extremely skewed, non-normal distributions so a logarithmic transformation was performed on each of these measures. No differences between the section types or the feedback types were found indicating that both versions were used similarly by students in both section types. Table 3 shows the mean and standard deviation usage values.

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Insert Table 3 about here.

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Academic Standing Across Usage Levels

Academic standing measures across section types and STAR usage levels were analyzed using a 2 x 4 analysis of variance. No significant differences between the two section types or between the STAR usage groups were found for any of the academic measures with the exception of high school rank where a main effect of amount of STAR usage was found, $F(3,761) = 3.99$, $p < .0078$. Results of Tukey's HSD test ($p < .05$) revealed that the users in the high STAR usage group had a significantly greater high school rank than the non-users of STAR. Table 4 shows the mean and standard deviation values for each academic standing measure. (Math and English SAT/ACT scores were converted to standard scores.)

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Insert Table 4 about here.

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Prediction of STAR Usage and Course Performance

A correlation of course performance, STAR usage, academic standing, and computer experience measures for students in each section type is shown in Figures 2 and 3. The correlations between the many variables show similar trends for both section types. Quiz average, final exam score, and number of quiz attempts appear to be highly intercorrelated. Standardized math and English aptitude test scores (SAT, ACT) were negatively correlated with number of quiz attempts; computer experience correlated only with standard math scores; and star usage measures were highly intercorrelated but not correlated with computer experience, academic standing, or course performance. Interestingly, the correlation between the final exam score and final quiz average was much higher for the students in the self-paced sections than in the lecture sections. Also, high school rank and GPA appeared to be related more to course performance measures for students in the self-paced sections than students in the lecture sections. The fact that there was not a correlation between the STAR usage variables (number of STAR quiz attempts, total time with STAR, total time with STAR feedback) and course performance (quiz average, final exam score) was not surprising since the correlation was based on STAR users only who, as a group, performed well in the course (regardless of usage level). Non-users of STAR were not included in the correlation because they did not have any STAR usage measures. Canonical correlations were calculated to determine the predictability of course performance and STAR usage from academic ability measures. Results showed academic standing measures (SAT/ACT english and math scores, GPA,

and high school rank) accounted for only 1% of the variance in STAR usage (number of practice quiz attempts, total time with STAR, total time with STAR feedback) and accounted for about 14% of the variance in course performance (final quiz average, final exam score). This suggests that while academic standing measures may be better predictors of course performance, they were very poor predictors of whether or not students used STAR.

## Discussion

This study sought to evaluate the adlib usage of STAR in the general psychology course at Texas Tech University. Results indicated that, when given the opportunity, approximately one-half of the students used the tutorial as a study tool. Classroom environment or the timing of the practice quiz question feedback did not have an impact on how or how often the students used STAR or how the students performed in the course. The results indicated that the students who used the tutorial, performed well in the course and as a whole better than those students who did not use the tutorial. There was a main effect of STAR usage on four course performance measures (quiz average, final exam score, total bonus points, and average number of quiz attempts). Further analysis revealed that STAR usage, at any amount, was better than no STAR usage. Additionally, no significant relationship was found between most of the academic standing and STAR usage measures indicating that a diverse group of students used the tutorial.

Since the students using STAR took more actual quizzes than the students who did not use STAR and since the most used module of STAR was the practice quizzes, it can be hypothesized that the primary mediator of course performance was quiz-taking (actual or practice). The students who performed well in the course were those who took advantage of the mastery approach to learning and took quizzes as part of their study routine. If this was true, the capability of STAR to provide practice quizzes may prove to

be an even greater asset in a course where frequent testing is not used. The results of this study are consistent with those of Grabe, et al. (1989) who found the use of interactive (computer-textbook) study methods yielded superior performance to traditional study methods. Grabe, et al. (1989) suggested, however, that the students who used their computer study system were more able than the students who did not use it and that use of the computer study system declined over the course of the semester. This did not appear to happen in the present study where students of varying academic abilities used the tutorial throughout the semester. If it were the case that students used the tutorial only a few times, it would not have been possible to divide the users into high, medium, and low usage groups (i.e. such would have been the case if STAR usage was based on the number of study sessions or the number of review performance sessions which were seldom used). Nevertheless, it is assumed that motivation played a major role in course performance and the use of STAR, as would be expected with any study tool. The present study, however, showed that close to 50% of the students voluntarily used the tutorial, a very high number for a typical college freshman course. It is possible that there was something special about STAR that may have sparked interest among those students not easily motivated, or perhaps the novelty of studying with the computer in addition to the textbook generated interest. Regardless, the results indicated that the students who used the tutorial, performed well in the course.

These results support the use of interactive computerized study tools in learning. The present research used the study tool in a computer-managed course setting where access to computers was generous and computer usage was an essential part of the course. More research is needed to determine the effects of such a tutorial in other types of course format (i.e., where computer use is not an integral part). It is assumed that, at least for the present environment, the computer-managed instruction coupled with access

to the STAR tutorial, provided an enhanced learning environment for teaching a large survey course.

Of course, simply providing the environment will not work alone. Student performance in the course is still dependent upon his or her own student study activities. Thomas and Rohwer (1986) describe studying as "private, self-directed, self-managed activities" (p. 19) initiated by a student. In other words, the student must want to study with a tutorial for it to be effective. Any study tool, regardless of its quality, can be worthless if it is not used or used incorrectly. In the general psychology course, the STAR tutorial was available to those who wanted to try it. It was observed that some students were disappointed to discover that STAR was not a magic tool which did the learning for them. STAR was simply a tool students could use to help direct their study time more efficiently.

Although the results presented were generally positive, the findings in this study pose several questions to be addressed in future research. First, since STAR usage is related to better course performance, then would simply increasing the number of users result in an even greater increase in performance? Second, since it appears that self-paced students performed at the same level as lecture students, should the self-paced class format be adopted for all class sections or should the lecture classroom format be modified so that it is more amenable to tutorial usage? Third, what would be the impact of a STAR-type tutorial in other course formats? One wonders whether STAR is effective only if it provides practice quizzes that are of similar format to the evaluation tests (i.e., multiple-choice) or if it leads to general increases in knowledge of the subject matter. Finally, how does STAR usage influence comprehension monitoring? One may assume from previous research that the use of the practice quizzes for study helped the students to accurately recognize what they understood and what they did not, but this is

not known for certain. Some of these issues are currently being investigated at Texas Tech.

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## Endnotes

[1] Development of the computer-managed instructional system was made possible through a NSF-CAUSE Grant SER-7907702 to Douglas C. Chatfield in 1981.

[2] STAR is currently under contract with Harper Collins/Scott, Foresman and Company and is available for several other introductory textbooks in psychology, history, and political science. Contact Dr. Charles G. Halcomb, Department of Psychology, Wichita State University, Wichita, KS 67208 for more information.

Table 1

Section Type By Amount of STAR Usage

| | AMOUNT OF USAGE (%) (n = 1136) | | | |
|---|---|---|---|---|
| | NONE | LOW | MEDIUM | HIGH |
| LECTURE | 53.73 | 17.01 | 14.18 | 15.07 |
| SELF-PACED | 45.78 | 19.04 | 16.63 | 18.55 |

Table 2

Means and Standard Deviations for Section Type by Amount of STAR Usage

| MEASURE | NONE | | LOW | | MED | | HIGH | |
|---|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | M | SD |
| TP - L | 109.79 | 59.33 | 134.54 | 32.81 | 136.04 | 30.83 | 148.15 | 21.26 |
| TP - SP | 126.01 | 54.89 | 137.12 | 36.67 | 137.42 | 36.86 | 150.60 | 19.93 |
| QA - L | 5.95 | 3.02 | 7.15 | 1.68 | 7.31 | 1.53 | 7.92 | 1.05 |
| QA - SP | 6.68 | 2.79 | 7.21 | 1.80 | 7.32 | 1.84 | 7.94 | .89 |
| FIN - L | 32.28 | 20.58 | 42.31 | 12.84 | 42.43 | 13.06 | 45.24 | 10.41 |
| FIN - SP | 35.27 | 18.98 | 40.30 | 13.76 | 39.40 | 13.47 | 42.72 | 8.39 |
| ATT - L | 3.30 | 2.35 | 4.10 | 2.16 | 4.30 | 1.88 | 3.99 | 1.87 |
| ATT - SP | 3.82 | 2.33 | 4.39 | 1.90 | 4.48 | 1.99 | 4.58 | 1.95 |
| BON - L | 20.91 | 13.01 | 28.27 | 9.56 | 27.83 | 9.77 | 27.63 | 9.26 |
| BON - SP | 24.23 | 12.48 | 28.34 | 10.42 | 28.15 | 10.23 | 30.19 | 8.45 |

L = Lecture; SP = Self-Paced; TP = Total Course Points; QA = Final Quiz Average; FIN = Final Exam Score; ATT = Average # Quiz Attempts; BON = Total Bonus Points

Table 3

Mean and Standard Deviation STAR Usage Measures by Feedback Type for each Section Type

| | AI | | EOQ | |
|---|---|---|---|---|
| | M | SD | M | SD |
| STAR QUIZZES-L | 1.31 | .45 | 1.27 | .48 |
| | (19.42) | | (17.62) | |
| STAR QUIZZES-SP | 1.32 | .47 | 1.28 | .49 |
| | (19.39) | | (18.05) | |
| STUDY SESS.-L | .36 | .38 | .39 | .37 |
| | (1.29) | | (1.45) | |
| STUDY SESS.-SP | .41 | .38 | .40 | .38 |
| | (1.57) | | (1.51) | |
| REVIEW PERF.-L | .40 | .42 | .47 | .41 |
| | (1.51) | | (1.95) | |
| REVIEW PERF.-SP | .50 | .45 | .40 | .45 |
| | (2.16) | | (1.51) | |
| FINAL EXAM-L | .23 | .31 | .20 | .25 |
| | (.70) | | (.58) | |
| FINAL EXAM-SP | .25 | .33 | .23 | .27 |
| | (.78) | | (.70) | |
| TIME W/STAR-L | 3.75 | .55 | 3.78 | .56 |
| (seconds) | (5622.41) | | (6024.59) | |
| TIME W/STAR-SP | 3.73 | .57 | 3.74 | .68 |
| | (5369.32) | | (5494.41) | |
| FEEDBACK TIME-L | 3.14 | .61 | 3.27 | .70 |
| (seconds) | (1379.38) | | (1861.09) | |
| FEEDBACK TIME-SP | 3.09 | .63 | 3.14 | .72 |
| | (1229.27) | | (1379.38) | |

L = Lecture Sections; SP = Self-Paced Sections; AI = After-Item Quiz Feedback; EOQ = End-of-Quiz Feedback (All means and standard deviations are logarithmic. Geometric means are shown in parentheses.)

Table 4

Mean and Standard Deviation Academic Standing Values by Section Type and Amount of STAR Usage

| MEASURE | NONE | | LOW | | MED | | HIGH | |
|---|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | M | SD |
| GPAF-L | 2.33 | .81 | 2.30 | .74 | 2.36 | .82 | 2.55 | .80 |
| GPAF-SP | 2.48 | .80 | 2.44 | .80 | 2.46 | .83 | 2.37 | .81 |
| GPAC-L | 2.31 | .75 | 2.32 | .74 | 2.34 | .79 | 2.54 | .77 |
| GPAC-SP | 2.45 | .77 | 2.40 | .76 | 2.43 | .80 | 2.37 | .82 |
| STENG-L | 491.81 | 99.20 | 512.25 | 97.32 | 492.46 | 103.98 | 503.48 | 99.86 |
| STENG-SP | 509.47 | 97.25 | 499.20 | 96.74 | 503.32 | 89.67 | 483.49 | 115.09 |
| STMTH-L | 487.91 | 100.31 | 515.25 | 97.32 | 492.46 | 103.98 | 503.48 | 99.86 |
| STMTH-SP | 500.42 | 96.41 | 499.20 | 96.74 | 503.32 | 89.67 | 483.49 | 115.09 |
| HSR-L | 49.55 | 9.96 | 49.92 | 10.00 | 49.89 | 9.83 | 53.34 | 8.44 |
| HSR-SP | 49.06 | 10.76 | 50.26 | 9.09 | 51.14 | 10.36 | 53.00 | 7.31 |

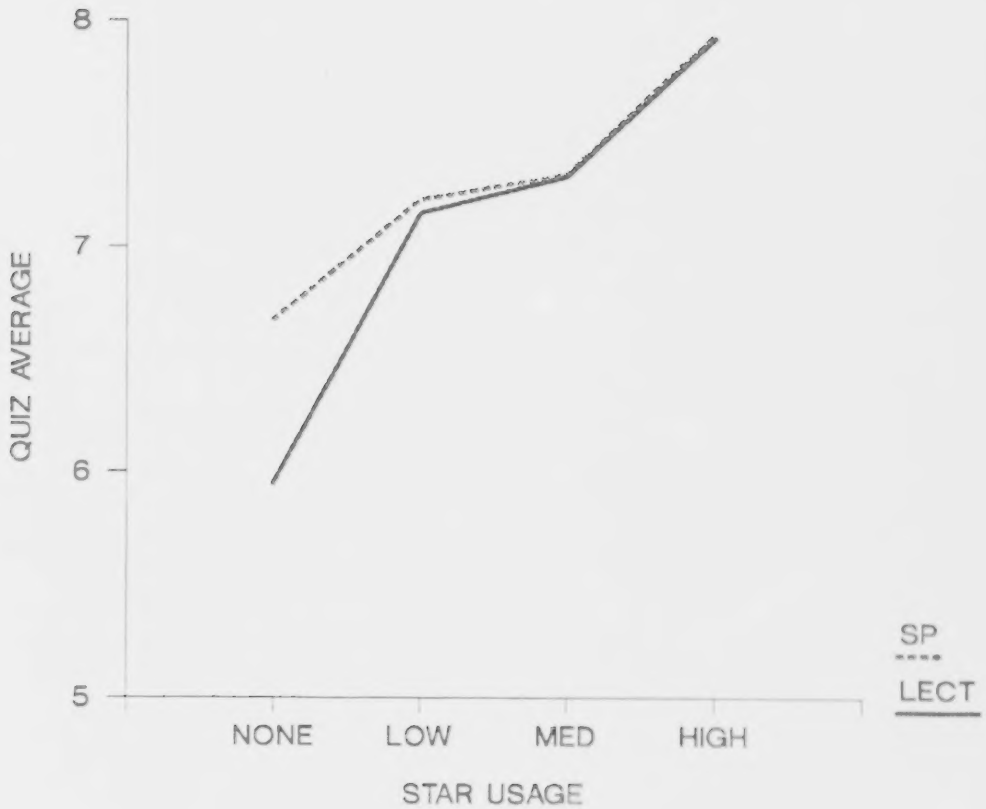
L = Lecture; SP = Self-Paced; GPAF = Fall 1988; GPAC = Cumulative College GPA; STENG = Standard English Score; STMTH = Standard Math Score; HSR = High School Rank

Figure Captions

Figure 1. Quiz Average for Lecture and Self-Paced Students by Amount of STAR Usage.

Figure 2. Correlation of Student Data in Lecture Sections (n=140).

Figure 3. Correlation of Student Data in Self-Paced Sections (n=116).


8
7
6
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QUIZ AVERAGE
NONE
LOW
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LECT

| | QAVG | FIN | ATT | ENG | MTH | HSR | GPA | CEXP | STME | SATT | STFB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| QAVG | 1.00 | .39*** | .27** | .22** | .20 | .20 | .33*** | .12 | -.02 | .16 | .06 |
| FIN | | 1.00 | -.21 | .31** | .22** | .002 | .10 | .23** | .08 | .08 | -.08 |
| ATT | | | 1.00 | -.50*** | -.36*** | -.10 | -.17 | -.08 | -.14 | .03 | .06 |
| ENG | | | | 1.00 | .58*** | .26** | .33*** | -.16 | -.07 | -.07 | -.10 |
| MTH | | | | | 1.00 | .29** | .34*** | .31** | -.10 | .09 | -.17 |
| HSR | | | | | | 1.00 | .44*** | .11 | .07 | .16 | -.01 |
| GPA | | | | | | | 1.00 | .08 | -.04 | .01 | -.08 |
| CEXP | | | | | | | | 1.00 | -.05 | .01 | -.14 |
| STME | | | | | | | | | 1.00 | .60*** | .49*** |
| SATT | | | | | | | | | | 1.00 | .58*** |
| STFB | | | | | | | | | | | 1.00 |

*** $p < .0001$; ** $p < .01$

QAVG = Quiz Average
FIN = Final Exam Score
ATT = # Quiz Attempts
ENG = SAT/ACT Eng. Score
MTH = SAT/ACT Math Score
HSR = High School Rank
GPA = College GPA
CEXP = Computer Experience
STME = Time with STAR
SATT = STAR Quiz Attempts
STFB = Time with STAR Feedback

Figure 2. Correlation of Student Data in Lecture Sections (n = 140).

| | QAVG | FIN | ATT | ENG | MTH | HSR | GPA | CEXP | STME | SATT | STFB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| QAVG | 1.00 | .78*** | .42*** | .11 | .14 | .39*** | .44*** | .002 | .08 | .15 | .10 |
| FIN | | 1.00 | .30** | .16 | .12 | .33** | .36*** | -.05 | .09 | .05 | .13 |
| ATT | | | 1.00 | -.36*** | -.17 | -.003 | -.11 | -.06 | -.01 | .03 | .12 |
| ENG | | | | 1.00 | .48*** | .44*** | .35*** | .002 | -.02 | -.05 | -.02 |
| MTH | | | | | 1.00 | .50*** | .33** | .16 | -.05 | .01 | .04 |
| HSR | | | | | | 1.00 | .48*** | .01 | .13 | .13 | .11 |
| GPA | | | | | | | 1.00 | .11 | .03 | .07 | .10 |
| CEXP | | | | | | | | 1.00 | .03 | .01 | .08 |
| STME | | | | | | | | | 1.00 | .63*** | .68*** |
| SATT | | | | | | | | | | 1.00 | .57*** |
| STFB | | | | | | | | | | | 1.00 |

*** $p < .0001$; ** $p < .01$

QAVG = Quiz Average
FIN = Final Exam Score
ATT = # Quiz Attempts
ENG = SAT/ACT Eng. Score
MTH = SAT/ACT Math Score
HSR = High School Rank
GPA = College GPA
CEXP = Computer Experience
STME = Time with STAR
SATT = STAR Quiz Attempts
STFB = Time with STAR Feedback

Figure 3. Correlation of Student Data in the Self-Paced Sections (n=116).